Deep-UV Distributed Feedback Laser Diode Design with Ultrawide Bandgap Semiconductor AlGaN

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Single longitudinal mode photon emission, desired in applications ranging from atomic clocks to optical fiber communications and quantum sensors [1], is possible to realize with semiconductor distributed feedback (DFB) laser diodes. DFB laser diodes of GaN and InGaN semiconductor heterostructures emitting in the visible wavelength have been realized [2, 3]. DFB lasers in the deep-UV spectral window currently remain out of reach due to lack of controlled doping of ultrawide-bandgap AlGaN, and lack of knowledge of optical coupling in UV.

We recently demonstrated distributed polarization-doped (DPD) pn diodes [4] to address the conductivity control, and optically pumped deep-UV AlGaN laser heterostructure [5] indicates AlGaN DFB laser heterostructures aimed for 270 nm are feasible. Achieving a high coupling coefficient κ is the key factor to obtain lasing, by lowering the threshold gain and threshold current density for a DFB laser. To that end we perform a theoretical investigation of the κ dependence on different ridge and grating depth designs. The κ, and therefore, optical loss, is determined from the fundamental mode profile using numerical simulations. Utilizing a fifth-order laterally-coupled surface grating with a 50/50 duty cycle, we find that a careful DFB structure design yields comparable threshold gain as laser diodes with highly reflective mirrors. The coupling coefficients evaluated here inform the design of the first low threshold electrically injected deep-ultraviolet semiconductor AlGaN-based DFB lasers.

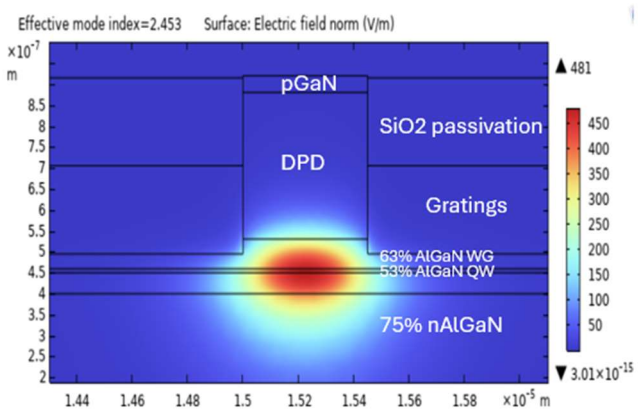

Fig.1. The contour plot for field density of a 450nm ridge width and 35nm grating depth into the waveguide.

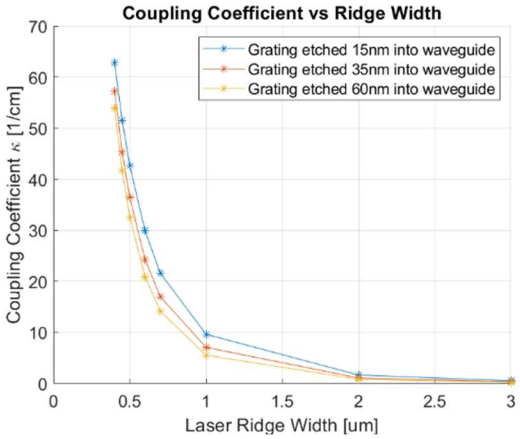

Fig.2. Calculated coupling coefficient for varying AlGaN semiconductor ridge width and grating depth.

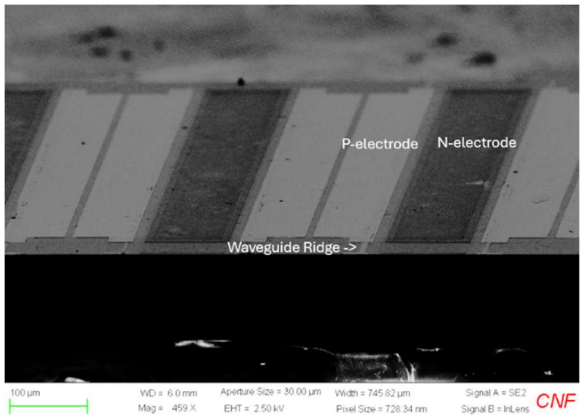

Fig.3. SEM image of a set of DUV AlGaN laser diodes in preparation for implementing surface gratings for DFB.

References

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